EXHIBIT 31

1 Calculation of velocity and temperature of heated air leaving the BH blanket

The objective of this report is to calculate the velocity and temperature of heated air as it leaves the BH blanket and enters the OR. In order to calculate the air temperature we need to calculate the heat transfer rate from the air to the patient's chest and arms. Since the heat transfer between the air and body occurs by forced convection, then we need to compute the velocity of the air as it moves between the BH blanket surface and the body.

1.1 Velocity of heated air leaving the BH blanket

Figure 1 shows the planar geometry of the BH blanket Model 522 before inflating it.

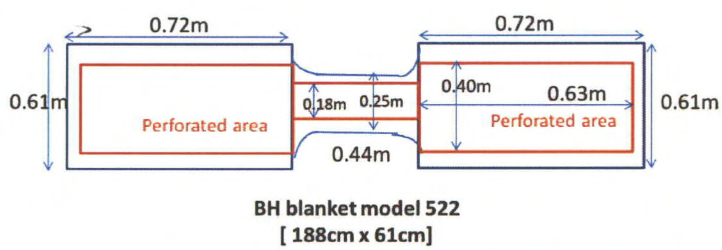

Figure 1: BH blanket geometry before inflation

In order to calculate the velocity of the air leaving the blanket we should consider the shape of the inflated blanket when it is connected to the BH blower as shown in Fig.2.

Bair Hugger
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Figure 2: BH Inflated Blanket. The dimensions with the red arrows are for PDF scaling only.

Fig.3 shows a cross-section of the inflated blanket after being wrapped around the arm.
The diameter of the cylindrical surface facing the arm $=0.194m$ which when unwrapped flat would produce the width of the blanket ($= 0.61m$) as shown in Fig.1, according to $L = \pi D$.
The width of the heated-air gap between the arm and the blanket surface $= \frac{(0.194-0.127)}{2} = 0.0335m$.
The heated air issuing from the blanket holes (one thousand holes, each 1mm diameter) leaves the blanket across that gap on the right and left arms.
The total cross-sectional area of both the right and left gaps

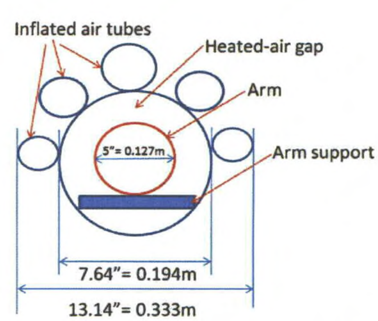

Figure 3: BH cross-section of inflated blanket

$= 0.0335 \times 0.61 \times 2 = 0.04087 m^2$.

Thus, **the velocity of air leaving the right and left arms**=

$$\frac{\text{Blower volumetric flow rate}}{\text{gap area}} = \frac{0.021\,\mathrm{m^3/s}}{0.04087\,\mathrm{m^2}} = \mathbf{0.514}\,\mathrm{m/s}$$

It should be noted that this is the velocity *before the air reaches the drape* that covers the blanket. The air will then leave the drape edges at a lower velocity as shown in Fig.4.

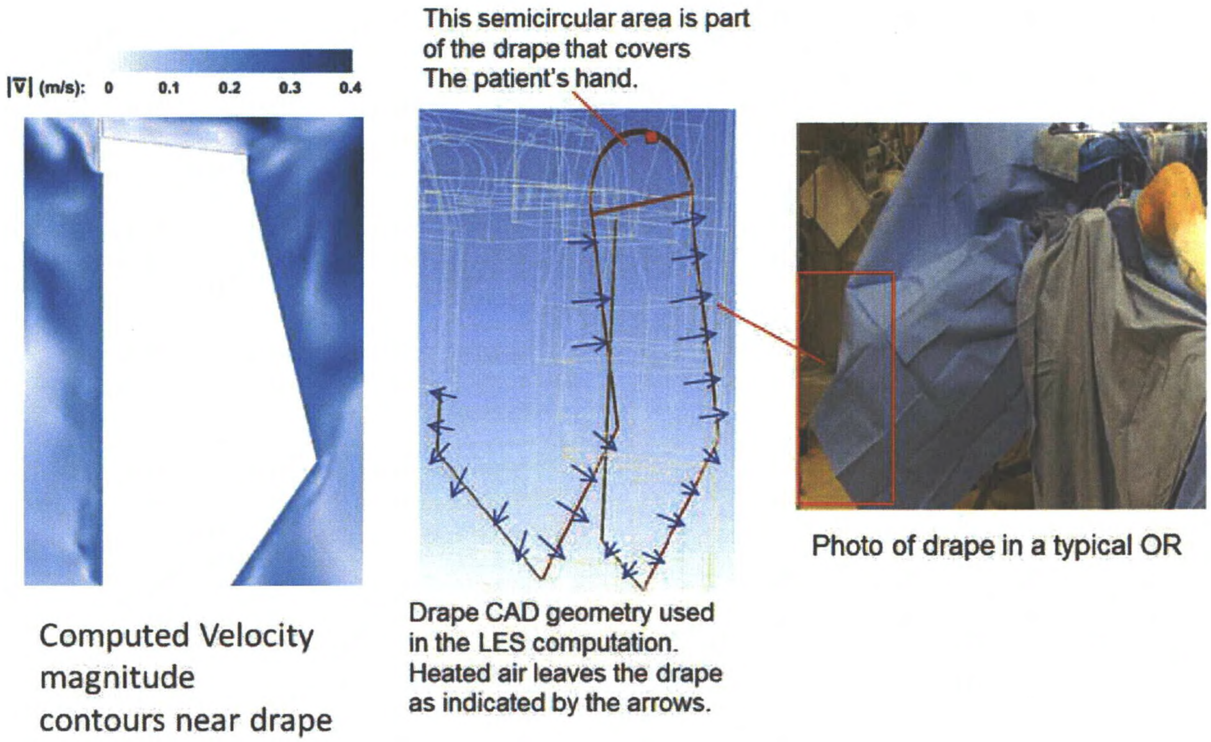

Figure 4: Drape geometry and heated air velocity near the drape.

1.2 Temperature of heated air leaving the BH blanket

In order to calculate the exit air temperature we apply the First Law of Thermodynamics to the control volume shown in Fig.5. For a steady-state condition we have:

$$\dot{m}_{in}\, h_{in} = \dot{m}_{exit}\, h_{exit} + \dot{q}_{body}\ , \qquad (1)$$

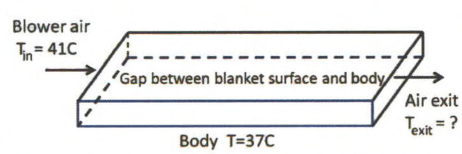

Figure 5: Schematic for heat transfer from air to body

where

$\dot{m}_{in}$= mass flow rate of blower air (kg/s)

= air density × volumetric flow rate = 1.1236 × 0.021 = 0.0236 kg/s ,

$\dot{m}_{exit}$= $\dot{m}_{in}$= $\dot{m}$ = mass flow rate of air leaving the blanket = 0.0236 kg/s,

h_{in}= enthalpy of air from the blower (kJ/kg),

h_{exit}= enthalpy of air leaving the blanket (kJ/kg),

$\dot{q}_{body}$ = rate of convective heat transfer from the air to the body (kJ/s= KW).

Since $\dot{m}$ is constant, Eq.(1) can be recast as:

$$h_{in} = h_{exit} + \dot{q}_{body}/\dot{m}, \qquad (2)$$

The inlet enthalpy, h_{in}, is obtained from Thermodynamics Tables of air (e.g. [2], page 660) at the temperature of 41C. The Table gives $h_{in} = 314\,\mathrm{kJ/kg}$. Our goal is to find h_{exit} since it

will give us T_{exit} via Thermodynamics Tables of air. Thus, we must first calculate the heat transfer to the body, $\dot{q}_{body}$.
Since the heat transfer from the air to the body is by forced convection, we have

$$\dot{q}_{body} = h_c \times \text{Area of blanket surface} \times (\mathrm{T_{air}} - \mathrm{T_{body}}) \ , \tag{3}$$

where h_c is the coefficient of convective heat transfer from air to body. This coefficient

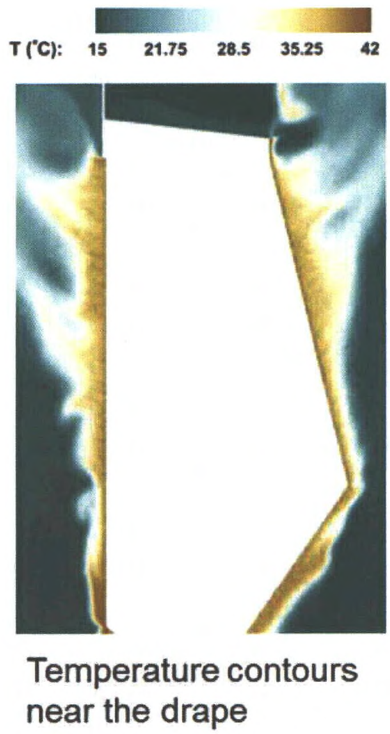

Figure 6: Heated air temperature near the drape.

depends on the air velocity that was calculated in the previous subsection as 0.514m/s. Reference [1] provides the values of h_c for different parts of the body as a function of the air velocity. For a velocity of 0.514m/s, $h_c = 5W/m^2K$. The temperature difference is $T_{air} - T_{body} = (41 + 273.15) - (37 + 273.15) = 4K$. The area of the blanket surface delivering the heated air is marked by the red contours in Fig.1:
Area$=2(0.63 \times 0.4) + (0.44 \times 0.18) = 0.5832\mathrm{m}^2$. Substitution in Eq.(3) gives:

$$\dot{q}_{body} = 5\mathrm{W/m^2K} \times 0.5832\mathrm{m}^2 \times 4\mathrm{K} = 11.664\mathrm{W} \tag{4}$$

Substitution in Eq.(2) gives:

$$314\,\mathrm{kJ/kg} = \mathrm{h_{exit}} + 11.664\mathrm{W}/(0.0236\mathrm{kg/s}), \tag{5}$$

which results in $h_{exit} = 314\,\mathrm{kJ/kg} - 0.494\,\mathrm{kJ/kg} = 313.506\,\mathrm{kJ/kg}$.
Using this value of h_{exit}, and the Tables in [2], page 660, gives $\mathbf{T_{exit}} = \mathbf{40.5C}$.

It should be noted that as the body temperature rises above 37C due to the continuous (e.g. for one hour) heating by air, the value of $\dot{q}_{body}$ will be reduced, and the exit air temperature T_{exit} will approach 41C asymptotically, as shown in Fig.6.

References

[1] R.J. de Dear, E. Arens, Z. Hui, and M. Oguro. Convective and radiative heat transfer coefficients for individual human body segments. *Int J Biometeorol*, 40:141–156, 1997.

[2] R.E. Sonntag, C. Borgnakke, and G.J. Van Wylen. *Fundamentals of Thermodynamics, 6th Ed.* Wiley, New York, 2002.

$\bar{\varphi} = \int \varphi x' \cdot \mathcal{G}(x, x')\, dx'$

filtering function

Not resolved

actual

$\varphi' = \varphi - \bar{\varphi}$

resolve

$\frac{\partial \bar{u}_i}{\partial x_i} = 0$

$\frac{\partial \bar{u}_i}{\partial t} + \frac{\partial \bar{u}_i \cdot \bar{u}_j}{\partial x_j} = -\frac{1}{\rho}\frac{\partial \bar{p}}{\partial x_i} + \frac{\partial \left(\nu\left(\frac{\partial \bar{u}_i}{\partial x_j} + \frac{\partial \bar{u}_j}{\partial x_i}\right)\right)}{\partial x_j} - \frac{\partial \tau}{\partial x_i}$

φ' Not resolved

$\frac{\partial \bar{u}_i}{\partial t} + \frac{\partial (\bar{u}_i \cdot \bar{u}_j)}{\partial x_j} = -\frac{1}{\rho}\frac{\partial \bar{p}}{\partial x_i} + \frac{\partial}{\partial x_j}\left(\nu\left(\frac{\partial \bar{u}_i}{\partial x_j} + \frac{\partial \bar{u}_j}{\partial x_i}\right)\right) - \frac{\partial \tau}{\partial x_i}$

$\frac{\partial \bar{u}_i}{\partial t} + \frac{\partial}{\partial x_j}(\bar{u}_i \cdot \bar{u}_j) = -\frac{1}{\rho}\frac{\partial \bar{p}}{\partial x_i} + \frac{\partial}{\partial x_j}\left(\nu\left(\frac{\partial \bar{u}_i}{\partial x_j} + \frac{\partial \bar{u}_j}{\partial x_i}\right)\right) - \frac{\partial \tau}{\partial x_i}$

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$\frac{\partial \bar{u}_i}{\partial t} + \frac{\partial (\bar{u}_i \cdot \bar{u}_j)}{\partial x_j} = -\frac{1}{\rho}\frac{\partial \bar{p}}{\partial x_i} + \frac{\partial}{\partial x_j}\left(\nu\left(\frac{\partial \bar{u}_i}{\partial x_j} + \frac{\partial \bar{u}_j}{\partial x_i}\right)\right)$

$\frac{\partial \bar{u}_i}{\partial t} + \frac{\partial}{\partial x_j}(\bar{u}_i \cdot \bar{u}_j) = -\frac{1}{\rho}\frac{\partial \bar{p}}{\partial x_i} + \frac{\partial}{\partial x_j}\left(\nu\left(\frac{\partial \bar{u}_i}{\partial x_j} + \frac{\partial \bar{u}_j}{\partial x_i}\right)\right)$

EXHIBIT B

References

[1] R.J. de Dear, E. Arens, Z. Hui, and M. Oguro. Convective and radiative heat transfer coefficients for individual human body segments. *Int J Biometeorol*, 40:141–156, 1997.

[2] R.E. Sonntag, C. Borgnakke, and G.J. Van Wylen. *Fundamentals of Thermodynamics, 6th Ed.* Wiley, New York, 2002.